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RESETTLEMENT ADMINISTRATION
Division of Land Utilization

Region VII
Lincoln, Nebraska

CRESTED WHEATGRASS

for

THE NORTHERN GREAT PLAINS

By
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FOREWORD

This report represents a compilation of information relative to crested wheatgrass and its possibilities for use in regrassing formerly cultivated land in the Northern Great Plains. The data have been assembled from the literature and from correspondence or interviews with men who have had experience with the grass in the field. Such conclusions and interpretations as have been made by the authors are largely based on this authentic published material. This paper covers no field research on the part of the authors nor on the part of the Resettlement Administration. All factual material can be found in the various sources which are cited.

The material herein assembled was compiled for the most part by Mr. V. H. Hougen during the summer of 1935. The present writer has rewritten the paper in an attempt to condense the same information into more concise form. Although some detail has been omitted, and a few additions and changes made, the actual subject material remains essentially unchanged.

As a result of the recent wave of interest in crested wheatgrass, several publications devoted solely to this species are available. These thorough and up-to-date reports have rendered a lengthy bibliography with this paper almost superfluous. The justification for the present report is that it is an attempt to segregate and summarize the information most pertinent to a program of land use adjustment in the Northern Great Plains. For those who wish to look further into the characteristics and potentialities of crested wheatgrass, the cited publications of Westover and of Kirk are especially recommended.

W. E. McQuilkin.

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INTRODUCTION

Crested wheatgrass (Agropyron cristatum (L.) Beauv.) is native to the cold dry plains of Russia and Siberia. It was introduced into this country in 1898, but did not attract much attention until 1915, and was not listed by commercial seedsmen until 1929. During the last ten years, there has occurred a constantly increasing interest in this grass for use in the northern plains of the United States and Canada. At present, it is being recommended very highly for this region.

Crested wheatgrass appears to embody a greater number of desirable features, and to have fewer faults, than any other species that has been tried. In general hardiness, drought resistance, length of growing season, feeding value, and seeding habits, it is considered to be unsurpassed. Consequently, it promises to be a most valuable contribution to western agricultural and livestock industries.

At the moment, seed supplies are inadequate to meet the demand, and prices are prohibitively high. This situation doubtless will be only temporary, and within a few years it should be possible to utilize the grass as extensively as its adaptations warrant. Indications are that it will partially usurp the place of bromegrass and slender wheatgrass in dry-land agriculture, and that it will be the most generally useful species available for the permanent regrassing of submarginal cultivated land in the Northern Great Plains.

HABITS OF GROWTH

Crested wheatgrass is a long-lived perennial, and grows typically in bunches or clumps. The bunches enlarge with age, both by tillering and by new shoots originating from short lateral rhizomes. The vigor of rhizome production varies considerably under different conditions or with different plants and their progeny. Hence, strains can be isolated which form a fairly uniform turf; in others, the identity of the original bunches is maintained indefinitely. The sod-forming tendency of this species never is as pronounced as it is in bromegrass, but it usually forms a closer and more uniform stand than slender wheatgrass. Bromegrass forms a sod so compact that the growth of foliage is stunted; slender wheatgrass, on the other hand, is so weakly stoloniferous that stands do not maintain themselves against the vicissitudes of nature. Crested wheatgrass represents a mean between the undesirable extremes exemplified by the above-named species. Its capacity for vegetative aggression in general is sufficiently vigorous to enable it to maintain itself without frequent seeding, but is not so vigorous as to result in a sod-bound condition. Hence, the productive life of stands of this grass generally is longer than is the case with slender wheatgrass and bromegrass.

The foliage of crested wheatgrass is moderately leafy, with an abundance of fine stems attaining a height of 2 or 3 feet. Unless the seasonal conditions are very adverse, a profusion of heads appears in June, and seed are ripe in early August. The spikelets are crowded on the head or spike, and tend to stand out at right angles. Because of this, the appearance of the heads is quite different from those of our common native wheatgrasses. Their resemblance to a crest has given rise to the common name of the grass.

An outstanding and valuable characteristic of crested wheatgrass is the length of its growing season. It is reported to start growth earlier in the spring than any other forage plant adapted to the northern dry plains. Under the conditions generally prevailing in that region, growth practically ceases during mid-summer, but with the advent of rains and lower temperatures, it is renewed and continued late into the fall.

In common with many other perennial grasses, the seedlings are delicate and slow-growing. The first few weeks after the germination of the seed constitute the most critical period in the life history of the plant. Six or eight weeks after planting, the seedlings begin to tiller (13).* Usually a few seed stalks are produced the first season, but the crop of forage is light and seldom worth harvesting. The end of the second season may be regarded as marking the complete establishment of the plants.

VARIETIES

Crested wheatgrass, as a species, is highly variable and offers attractive possibilities for the segregation of strains superior to the mixed common stock, or adapted to particular uses. Some work along this line has been done both in this country and in Canada. From the strains tested at the Great Plains experiment stations, one designated as S.P.I. 19537 has appeared to be the most satisfactory. All registered crested wheatgrass seed grown in Montana traces to this selection (22). A strain, designated as "Fairway" (S-10), has been developed at the University of Saskatchewan. The plants of this selection are uniformly a little shorter, more leafy, and more inclined to spread and form a turf than are those of common commercial stock (12). The yields are not significantly different. This strain thus is well adapted for pasture usage, and is suitable for unirrigated lawns and golf course fairways.

* Numbers in parentheses refer to Literature Cited, page 23

ADAPTATIONS

Climatic adaptations. The most significant climatic adaptations of crested wheatgrass are its tolerance of drought and its capacity for growth at relatively low temperatures. It perhaps is debatable whether the factor of low temperature should be regarded as a matter of tolerance or as a requirement. It is generally affirmed that this grass grows earlier in the spring and later in the fall than most other plants, that it seems practically to be immune to winter injury, that it withstands drought better under the cooler conditions prevailing northward, and is unsuited to the climate of western Kansas and similar regions. However, the evaporation stress of the atmosphere increases with higher temperatures, and a given amount of rainfull is thus more effective at northern latitudes or higher elevations. There are some indications that the grass will thrive south of the 40th parallel when moisture is plentiful. Regardless of theoretical considerations, cool climatic conditions may be regarded from a practical standpoint as a requirement for the successful culture of the species. Its use in Kansas, southern Colorado, and southward will be confined, for the most part, to elevations greater than 5000 feet. It may have a limited value in moist valleys or under irrigation, but its possibilities in such situations are not as yet clearly determined.

Crested wheatgrass has proven successful at nearly all the experiment stations in the plains of Montana (9, 22, 29), Wyoming (15, 19), and the Dakotas (2, 4, 23, 28). It also has given some good results in the western mountain and inter-mountain range lands (3, 5, 7), and in the prairie provinces of Canada (12). Eastern Colorado and western Nebraska apparently represent the transition zone between the generally favorable region to the north and the generally unfavorable region farther south. Attempts to cultivate the grass in the plains area of those two states will be an uncertain venture, but in all probability will result in some measure of success. According to reports from Colorado, seedings usually have failed on the dry plains in the vicinity of Akron and Wray (14, 26), but have succeeded in the foothills near Fort Collins (6). Stewart and Gross (25) suggest the use of the species in western Nebraska, but apparently it has not been extensively tested in that state.

Authorities are generally agreed that crested wheatgrass is highly drought resistant under conditions prevailing in the Northern Great Plains. This does not mean that the grass actually will grow during extreme drought, but rather that it will make better growth than most other plants during periods of moisture deficiency, and that it can endure protracted periods of drought without permanent injury. Kirk (11) briefly discusses this point and classes crested wheatgrass among truly drought resistant species. During a series of dry years at Saskatoon, Saskatchewan, slender wheatgrass died out to the extent of 75 per cent or more, while crested wheatgrass under the same conditions suffered little permanent injury, and continued to produce some pasturage and harvestable hay. Sloan (22) records some results at Havre, Montana, during the same period (1928-1932). Plantings of bromegrass, slender wheatgrass, and crested wheatgrass were made in 1927, and almost perfect stands of each species were obtained in both row and close drilled plots. Crested wheatgrass maintained its full stand during the entire period, but by 1932, the bromegrass plots were reduced to 28 per cent stand in close drilled plantings and 58 per cent in row plantings.

Slender wheatgrass stands were reduced to 16 and 2 percent respectively by 1931, and by 1932 the loss in stand was practically complete. The summarization of the experience with crested wheatgrass compiled by Westover and his associates (28) supports the contention that this species is more drought resistant and generally more dependable than other forage plants suited to the Northern Great Plains.

The capacity of crested wheatgrass to grow under conditions of moisture deficienty is correlated with its exceptionally efficient root system. Kirk (11) has shown that the root systems of this species possess more than twice as much dry matter, the main root mass extends twice as deep, and the development of fibrous branches is much more extensive than are those of slender wheatgrass. Love and Hanson (13) examined the root systems of crested wheatgrass growing at Fargo, North Dakota. They found that the stronger roots reached depths of 7 to 8 feet and that the main root mass, i.e., the working depth of the root system, extended more than 3 feet deep. The roots of bromegrass were found to attain approximately the same depths, but those of crested wheatgrass spread more widely, had a much greater number of branch roots, and thus apparently possessed a much greater absorbing surface. That crested wheatgrass roots are highly efficient in withdrawing available water from the soil is attested by the fact that weeds are unable to compete with established plants. At Manyberries, Alberta, weeds were unable to compete, even when the grass was planted in rows, and plots remained clean without benefit of inter-tillage (11).

Soil adaptations. Crested wheatgrass is highly adaptable with respect to soil types. Apparently, it thrives best on those of medium texture and fairly high fertility. The results obtained at Dickinson and Mandan, North Dakota, at Ardmore, South Da ota, at Archer and Sheridan, Wyoming, and elsewhere, indicate that it is adapted to a wide range of soil types (28). In Canada and Montana, it has given good results on soils ranging from light sandy loams to heavy clays (12, 22). Johnson (10) states that the species is particularly promising on the sandy soils of western South Dakota. Hanson (7) reports good results from seeding crested wheatgrass on gravelly cultivated land near Fort Collins, Colorado. In trials at the Judith Basin Substation in Montana, where the soil is described as a heavy clay loam with gravelly subsoil, this species gave better results than other cultivated grasses (29).

Soils that are amply supplied with lime are most favorable for the growth of crested wheatgrass (12). No statement has been seen relative to its tolerance of soil acidity. Inasmuch as practically all soils in the Great Plains area are circum-neutral to alkaline in reaction, the factor of acidity will be of little practical significance. The tolerance of the grass to soil alkali cannot be definitely stated. Kirk (11) is of the opinion that it is less tolerant than slender wheatgrass and more tolerant than bromegrass. This can be interpreted to mean that concentrations as high as 0.5 percent, and possibly as high as 0.7 percent of salts by dry weight in the soil will not preclude the use of crested wheatgrass. However, the native western wheatgrass (Agropyron smithii) will in general be the most practicable species for use on soils with a high content of alkali.

CULTURE

Preparation of seed bed. Authorities quite unanimously emphasize the fact that the seedlings of crested wheatgrass are delicate, and that a carefully prepared seed bed is one of the major requisites for successful seeding. Westover (28) states that crested wheatgrass requires the best possible conditions for germination and early growth. "A fine, firm seed bed well supplied with moisture is essential to a satisfactory stand." Corn land or summer fallow generally supplies that condition. A good seed bed may be prepared on fall or spring plowed grain stubble. It is emphasized that the land should be worked down well, smoothed with a spike-toothed harrow, and packed if necessary just before seeding. It is suggested that where weeds are abundant, better stands result from two or three cultivations with a disk harrow, a spring-tooth harrow, or a duck-foot cultivator before seeding. Sabin (19) in Wyoming recommends that crested wheatgrass be seeded on land prepared as it is for spring wheat. Sloan (22) in Montana states that seedings on a firm, moist, unclodded seed bed, which has been cleanly cultivated to a shallow depth, and in which there is an accumulation of sub-soil moisture gives the best results. He recommends summer fallowed fields, and disced corn or potato ground free from weeds as usually having a good supply of moisture. In his opinion, spring or fall plowed stubble ground usually fails to meet these requirements.

Canadian authorities (12, 24) likewise emphasize the importance of a good seed bed that is well worked down, firm, level, free from weeds, and containing sufficient moisture near the surface to permit quick germination and rapid growth of the seedlings. They recommend summer fallow, corn or potato land, and spring or fall plowed stubble. The latter is somewhat more dependent on current rainfall, and requires packing to obtain the necessary firmness.

Numerous attempts to establish grasses on depleted range lands have been made without seed bed preparation. The great majority of these have failed. Sampson (20) diagnosed 61 of 168 failures among his own experiments as being due to inadequate soil treatment. Seeding cultivated land with little or no preparation presents a somewhat different problem on which there is little experimentally confirmed information. Although seeding in grain stubble prepared only by discing generally is considered inadvisable, good results with crested wheatgrass have been obtained at the Archer Field Station in Wyoming by that method (15).

It is most desirable that some means be found for regrassing cultivated land at low cost. There are huge areas in the northern plains where land values scarcely justify the expense of seeding, if plowing, harrowing, and packing must be figured in planting costs. Some effort to meet this situation has been made in Montana and Canada. The Northern Rocky Mountain Forest and Range Experiment Station has conducted cooperative experiments with farmers in Montana, in which various grasses and legumes were drilled in abandoned cultivated land without any preparation except to burn the weeds where they interfered with drilling.

Preliminary results indicate success, according to range reseeding standards (at least one plant per square yard), on about 40 per cent of the acreage sown. These trials were in progress during the extreme drought of 1934. The results are particularly encouraging in view of that fact. Crested wheatgrass appears to be the most promising species tried under these conditions (9).

In some experiments of a similar character at Manyberries, Alberta, seeds were broadcasted in an abandoned field and covered by discing. The field was part of a summer grazing area, and no protection was supplied. Three years after seeding, crested wheatgrass was the only one of the planted species that persisted. The others, including bromegrass, slender wheatgrass, and sweet clover, either failed to become established, or succumbed to grazing injuries (11).

Time of seeding. Practically all authorities are agreed that crested wheatgrass is best sown in the spring in the Northern Great Plains. Sloan (22) and Westover (28) recommend that it be sown at about the time that spring wheat is seeded locally. Moisture conditions are likely to be most favorable at that time. The best date for seeding varies with seasons and localities. Soil moisture is the most critical factor. In Montana, May 1 has proved to be the best date at the Judith Basin Substation, while May 10 to June 1 is recommended at the substation at Havre farther north. Westover remarks that delayed seeding is advisable when the soil is dry, or when badly infested with weeds. In the latter case, time is allowed for germination of weed seed and subsequent cultivation before planting. Ordinarily, seeding should not be delayed later than June 1.

Fall seeding has been practiced to some extent and has given some good results. Sloan states that this season involves greater risk, as weed infestation generally is heavier the following spring than when the land is surface-cultivated and seeded in the spring. Westover points out that, although fall seedings give good results in some localities, they are generally more vulnerable to injury by cold or dry weather, or by grasshoppers. Kirk (12) considers the autumn season to be less favorable than early spring in the Canadian prairie provinces. When fall planting is to be done, late August to early September is the most favorable period. Kirk states that seed sown between June 15 and August 15 frequently fails to produce a crop. A seeding date later than mid-September is inadvisable, because the seedlings do not have sufficient time to become established before winter sets in.

A second and less frequently considered period for fall seeding can be dated after November 1. Seeds planted at this time do not germinate until the following spring. If the dangers from weed competition are not too great, this method sometimes gives good results. Sloan (22) and Hurtt (9) have found it to be a practicable method in Montana on cultivated land that had received no seed bed preparation. The seed of most hardy perennial grasses can lie on or in the soil over winter without injury, and may lie over an entire year when dry conditions prevail (9). Fall sowing, with either fall or spring germination, is, of course, nature's way of seeding. At present, there is insufficient evidence to warrant any positive conclusion with respect to late fall planting in the Great Plains.

However, it would seem to merit consideration, particularly when seeding is done under the semi-natural conditions prevailing on unprepared soil.

Methods of seeding. Drilling is the most common and the most successful method of seeding. The double-disk drill is preferable to the single-disk drill, as it does not cover so deeply. The furrow type of drill is somewhat superior to the disk types because with it the seed are more likely to be placed in contact with firm, moist soil (15, 19). Furthermore, the ridges left by a furrow drill may serve in some measure to reduce soil blowing.

The seed may be close drilled, or spaced in single or double rows 36 or 42 inches apart. Double rows have been favored in some sections because the chances for completely blank spaces are thereby reduced. Row planting is done with an ordinary drill by plugging such spouts as is necessary to get the desired spacing. For double rows, two adjacent spouts, instead of one, are left open at appropriate intervals on the drill. Row planting is especially practicable for seed production, and in dry seasons, frequently results in the greatest production of hay. At this time of shortage and high prices of seed, planting in rows is the most feasible means of getting the grass started. If it is allowed to go to seed undisturbed, the spaces between the rows are soon occupied by volunteer seedlings and a full stand ultimately is obtained.

Another delayed method of getting a stand with a minimum amount of seed is by strip planting. In this case all the drill spouts are left open, but sowing is done in drill-width strips at intervals of several rods across the field (1). The intervening spaces are filled in later by volunteer seedlings.

The seed feed fairly satisfactorily through the mechanism of the ordinary drill box. It is recommended that the box be only about one-third filled at a time, that the seed in the box be leveled frequently, and carefully watched to see that all spouts are feeding properly. Clean, heavy seed will give little difficulty; light, poorly cleaned, or chaffy seed will be more inclined to clog in the spouts.

It is possible to use various other types of seeders, or to scatter the seed by mechanical of hand broadcasting. However, these methods all require harrowing, which at best is less efficient for covering the seed than a regular grain drill. In consequence, more seed are necessary to get a given density of stand (12, 15), and the chances for failure are greater.

As a general rule, nurse crops are not recommended for dry regions (12, 28), although good results have been obtained by seeding with wheat or oats where the moisture conditions were favorable. When a nurse crop is used, it should be seeded at about one-half the usual rate, and should be removed early for hay rather than allowing it to ripen grain. Nurse crops may be advisable in places to reduce soil blowing while the slower crested wheatgrass plants are getting started. Kirk (12) recommends in this connection that wheat or other grain be sown in rows 3 or 4 feet apart, and that the seeding of the crested

wheatgrass be delayed until the grain plants are 3 or 4 inches in height.

Depth of seeding. The seed of crested wheatgrass usually was covered too deeply during the first years it was planted. Experiments have shown that emergence decreased with depth of planting below $\frac{1}{2}$ inch (12, 13). The reserve materials stored in the seed are only sufficient to develop a shoot about 1.5 inches long (12). The vigor of the emerging seedling decreases as depletion of food reserves in the seed is approached. The chances for survival consequently are reduced when those reserves are near exhaustion by the time the seedling breaks through the soil.

Though the seed will germinate on the surface of the soil if moist conditions are maintained, seeding without some provision for coverage is never to be recommended for the plains region. The optimum depth, when sufficient moisture is present, is $\frac{1}{4}$ to $\frac{1}{2}$ inch (13, 24, 28). Planting as deep as 1 inch may be advisable if such depth is necessary to insure contact with moisture (8, 15). Greater depths result in low percentages of emergence, and are not recommended under any circumstances. It is in connection with the necessity for shallow planting that a firm, smooth seed bed and a judicious choice of seeding date are most significant.

Rate of seeding. Considerable latitude is possible as regards rate of seeding, inasmuch as crested wheatgrass has demonstrated such marked ability to thicken by volunteer seeding, as well as by vegetative means. Piper (18) and Westover (28) advise seeding 10 to 12 pounds of seed per acre for close drilling, Semple (21) says 12 to 15 pounds, and Kirk (12) recommends 15 pounds for the Canadian prairie provinces. Such rates of sowing may be expected to give fairly close stands approaching maximum productivity as soon as the plants are established. The seed of this species usually show a high percentage of viability, and they are fairly small. A pound of the seed represents a greater number of potential plants than do equivalent weights of the seed of bromegrass or slender wheatgrass.

Thinner seedings are preferable under drier conditions, and perhaps are generally advisable at present because of the shortage of seed and high costs. Seeding rates varying from 6 to 10 pounds per acre have been successfully employed at several of the experiment stations, and are recommended by them (15, 19, 22, 25, 29). Kirk (12) points out that under the arid conditions of southwestern Saskatchewan and southern Alberta, the amount of seed should be reduced to about 10 pounds per acre.

Broadcasted sowings, as previously indicated, require more seed to obtain a given density of stand. On the basis of 15 pounds of seed per acre for drilling, Kirk recommends 20 pounds when sown broadcast (12).

When the grass is drilled in rows 3 or 3.5 feet apart, considerably less seed is required. Two to three pounds per acre for single rows, and four to five pounds for double rows is considered sufficient (12, 28).

It may require some experimentation on the part of the drill operator to get a desired rate of seeding, as lots of seed vary in their freedom from chaffy debris, in weight, and sometimes in the development of awns. Such factors influence the readiness with which the seed flow through the drill cups. Westover (28) suggests setting the drill at about one-half the usual rate of seeding wheat when it is desired to sow 10 to 12 pounds of crested wheatgrass seed per acre. Nelson (15) set the drill to seed 1 peck of wheat per acre. He does not specify the exact rate at which crested wheatgrass was seeded by this setting, but intimates that it was somewhat less than 10 pounds per acre.

Mixed seedings. Crested wheatgrass appears to be well suited for seeding in mixtures, as well as in pure stands. Mixtures of forage plants are generally considered to make more palatable feed for stock, yields in some instances are increased, and the length of the grazing season usually is prolonged because of the different growth periods of the component species. Mixtures of alfalfa or sweet clover with grass nearly always give yields higher than those of the grass alone, and sometimes higher than those of the legume alone (15, 28).

In addition, the presence of these legumes tends to prolong the productive life of the grass (15). Recent experience in Nebraska indicates that the danger of livestock losses from bloat on alfalfa or sweet clover pasture is materially reduced when the legume is grown in mixture with palatable grasses. If, in addition, precautions are taken to insure ample supplies of water for the stock at all times, and to prevent grazing the legume when the growth is very young, or when the stock are empty, these mixtures may be pastured with a reasonable degree of safety.

Crested wheatgrass also may be used in mixture with other grasses with good results. With the present scarcity and high prices of seed, sowing in mixture may be a very feasible means of introducing the species into an area without sacrificing completeness of ground cover. With short-lived grasses, such as slender wheatgrass, the crested wheatgrass may be expected to spread as the associated species declines in the stand. With a persistent and aggressive species such as bromegrass, crested wheatgrass probably would not replace it in a mixture under ordinary circumstances, but the forage should be equal to, or better in quality and quantity than that of either species growing along. The possibility has been suggested, though not experimentally demonstrated, that the presence of a bunch grass will delay the advent of the sod-bound condition so prevalent in old bromegrass sods.

There are few specific recommendations as to amounts of seed to use in mixed plantings involving crested wheatgrass. Westover (28) suggests that, for a crested wheatgrass-alfalfa mixture, 3 or 4 pounds of the grass seed be sown per acre with "a little less than the usual quantity of alfalfa seed when sown alone". Morris (14) suggests a mixture of 7 pounds of crested wheatgrass, 8 pounds of bromegrass, and 2 pounds of yellow-blossom sweet clover seed per acre for seeding in the foothills of eastern Colorado. In view of the fact that crested wheatgrass often is sown alone at rates of 10 pounds or less of seed per acre, it would seem that the amount of grass seed in the above mixture might well be reduced for use in the drier situations on the plains.

Care after seeding. Protection against grazing animals during the first season probably is the most important measure with respect to care after seeding. Though trampling and the removal of leaves are injurious, the most critical consideration is the actual pulling of young plants by the animals. By the fall of the first year, the plants will have begun to tiller, development of the secondary root system will be well started, and the plants will be less susceptible to uprooting. Some light grazing might then be permitted without serious loss of plants, but their establishment will be most favored by deferring grazing until well into the second year. Ordinarily, the growth of foliage the first year will not be sufficient to harvest for hay.

Where weeds are rank and abundant, it is considered advisable to clip them once or twice during the first year. The mower should be set high to minimize injury to the grass. If the weeds are not introducing serious competition for nutrients or light, the field may best be left undisturbed. The standing plants will be beneficial in holding snow during the winter. Furthermore, crested wheatgrass ordinarily produces a few seed the first year. Mowing, at best, will destroy most of these seed stalks and thus preclude the appearance of volunteer seedlings. Weedy fields may be burned in early spring without injury to the grass, according to Westover (28) and Sloan (22). The material should not be piled or raked together, as the burning then is likely to kill the plants underneath. If the grass withstands the competition of weeds during the first season, it will in all probability control the area thereafter, and weedy species will largely disappear. Under properly regulated grazing, the grass will maintain itself for years without deterioration of the stand.

When crested wheatgrass is grown in rows, some cultivation is necessary if the rows are to be maintained. Cultivation the first year is a weed-controlling measure; in subsequent years it becomes necessary also in order to destroy volunteer seedlings. In some situations, weeds make but little growth between rows of established plants (11, 12); under other circumstances, they may continue to be troublesome and necessitate frequent cultivations (28). Inasmuch as the root systems of the grass spread laterally 1.5 to 2 feet from the crowns, cultivation should be no deeper than is required to destroy the plants between the rows. Stirring the soil deeper than 2 or 3 inches, thereby breaking many of the roots, obviously is injurious to the grass plants and will preclude the attainment of maximum development and yields.

All reports indicate that the productive life of crested wheatgrass is longer than that of bromegrass and slender wheatgrass. However, yields do tend to decline on old stands. Older stands appear to require more moisture than new ones, probably owing to the fact that there has been considerable thickening and that there may be a shortage of subsoil moisture (28). Though Sloan (22) states that "old fields seeded solid are often cultivated early in the spring in order to thin the stand and encourage seed production", recommendations to this effect are singularly lacking in the literature as a whole. It may therefore be inferred that cultivation of close stands has not been generally practicable as a means of improvement. As a result of experiments at Archer, Wyoming, it was concluded that tillage was of little or no value in increasing the yields of hay (15). Fertilization, either in the form of manure or through the admixture of sweet clover

in the stand, proved to be of distinct value in prolonging the productive period of crested wheatgrass sod at this station. The introduction of sweet clover gave the best results as a treatment for rejuvenating old sods.

GRAZING

Seasonal productivity. Practically every publication dealing with crested wheatgrass mentions its early growth in the spring. This is a most desirable character. It thereby becomes possible to get stock on grass 2 to 4 weeks earlier in the spring than when dependence is placed entirely on the native ranges. Reports vary somewhat with respect to the actual time interval by which crested wheatgrass antedates the growth of other species. Apparently, it may be expected to begin growth from a few days to 2 weeks earlier than bromegrass and slender wheatgrass, and sometimes as much as a month in advance of the native buffalo and grama grasses.(7, 11, 14, 22, 28). Regardless of actual starting dates, authorities almost unanimously agree that crested wheatgrass furnishes earlier grazing than other pasture plants. At Mandan, North Dakota, it is said to start growth about April 1, and to be ready for grazing about 3 weeks later. Bromegrass and slender wheatgrass lag behind crested wheatgrass approximately 1 week (28). Plath (17) notes that it was ready for grazing by April 10 in 1928 at the Hettinger Substation in North Dakota. Hanson (7) reports that the growth was 2 to 6 inches high by March 8 in the foothills of northeastern Colorado. Cole (4) has reported the dates on which various species were ready for grazing at Ardmore, South Dakota. His observations were tabulated below:

	1923	1924	1925
Crested wheatgrass	May 4	April 28	April 27
Bromegrass	May 7	May 1	April 27
Sweet clover	June 28	May 15	June 15
Native grasses	May 16	May 15	April 30

It will be noted that crested wheatgrass is somewhat earlier than the other species, though the difference between it and bromegrass is almost negligible.

Although the above represents the observations commonly reported in the literature, the comments and data of Christ (3) should be noted. He maintains that there is little difference in the actual dates at which the common grass species start growth in the spring, and that statements to the effect that a given grass "starts growth early in the spring" are of questionable accuracy. According to his observations, the significant difference between species is that some "come to more rapid early season growth" than others. He presents a tabulation of agronomic data for grasses grown at the Sandpoint Substation in northern Idaho. In this, under the heading "Rapidity of early growth", crested wheatgrass is listed as "moderate"; slender wheatgrass likewise is listed as moderate; and bromegrass is listed as "fast". The actual dates on which growth started are April 6 for crested wheatgrass and slender wheatgrass, and March 29 for bromegrass. It may be added that these dates are the latest and the earliest ones recorded in connection with the 16 species of grasses under test.

There is no obvious explanation as to why Christ's observations are at variance with the general consensus of opinion. However, the attention which he has given to the subject warrants recognition, and indicates, at least, that crested wheatgrass can not be expected to antedate other grasses under all conditions.

Authorities generally emphasize the fact that crested wheatgrass is a cool-season crop and can not be depended upon for mid-summer grazing, unless the spring growth is allowed to cure on the ground. It makes the major part of its vegetative growth during the cooler spring months, and becomes practically dormant in hot, dry weather. When ungrazed, flowering begins in late June, and the grass begins to mature in late July at Dickinson, North Dakota (28). In the fall, especially if moisture is present, it revives and provides good pasturage until freezing conditions prevail.

The greatest feeding value always is to be derived from forage by utilizing it in the green, growing state. The best management practices will be directed toward providing green pasture for as much of the season as possible. Johnson (10) has pointed out that crested wheatgrass can be most efficiently utilized for early spring grazing, after which the stock can be moved to the native ranges for the summer season. Continuous green pasturage can be most closely approached by a combination of native range and planted pastures involving several species. In such a scheme, crested wheatgrass probably would be most valuable when used at the two extreme ends of the season--early spring and late fall.

Resistance to grazing and trampling. One of the major problems of range management is to supply the need for early spring grazing with a minimum of injury to the range. Damage is particularly likely to result at this season, both from trampling while the ground is soft and from the too early removal of the young grass leaves. Because of its very dense and efficient root system, crested wheatgrass withstands trampling better than many species. It is unusually tolerant to early spring grazing, which apparently is due to its capacity for vigorous growth during this period. This should not be interpreted as a license to subject crested wheatgrass pastures to unlimited abuse, but simply that it does rank high in tolerance to such treatment. Undoubtedly, conservative management of this species is most conducive to sustained high returns, as is true of other kinds of pasture.

It can generally be inferred from the literature that crested wheatgrass is remarkably tolerant to, and persistent under close grazing. Kirk (12) makes the most positive statements in this connection. He reports that a field at the Dominion Range Experiment Station withstood close continuous grazing from early spring to late fall for 5 years in succession without apparent injury to the grass. Sabin (19) points out that heavy trampling and overgrazing must be avoided on sandy soils, and suggests that bromegrass may be better suited to such situations.

Carrying capacity and pasture value. The available data pertaining to the carrying capacity of crested wheatgrass have been obtained at the experiment stations from small, and usually carefully managed pastures. The figures probably are somewhat higher than an average figure for the general region would be. However, these data are valuable from the standpoint of comparison with other grasses, and as a general basis for estimating carrying capacities.

At Ardmore, South Dakota (4, 28), an experiment was conducted with dairy cows on crested wheatgrass, bromegrass, native grass, and sweet clover pastures. Records were obtained for 4 years on the basis of grazing seasons averaging 112 days in length. In addition to the acres required per cow, the value of the pasture was figured in terms of the monetary value of the alfalfa hay and corn silage that would have been required to furnish an equal quantity of nutrients. Nutrient requirements were based on the amounts of milk and butterfat produced. The summarized data are tabulated below, together with a calculation of the acreages required for an 8-months grazing season.

	Acres per cow		Value of nutrients
	112 days	8 months (calculated)	(112 days)
Crested wheatgrass	2.73	5.8	$7.70
Bromegrass	3.17	6.8	6.75
Sweet clover	2.70	5.8*	6.63
Native grasses	4.45	9.5	4.43

It is recognized that the acreage required for a season longer than that used in the experiement can not be accurately determined by simple extrapolation. Figures obtained in this way must be accepted only as approximations. Cole (4) states that "the number of days of pasture from the cured standing native grasses was less than half that from these native grasses when pastured while growing and green".

At a later date, Baker (2) reported the results of a grazing experiment with beef steers at the same station. Crested wheatgrass and native pastures were compared over a period of 3 years. The average figures show the crested wheatgrass to be markedly superior in carrying capacity, as shown by the acres per steer and gains per acre in the following tabulation:

	Crested wheatgrass	Native grass
Length of grazing season (days)	110	114.5
Acres of pasture per steer	6	10
Average gain per steer (lbs.)	186.7	180.7
Average gain per acre (lbs.)	31.1	18.1

This trial covered the years 1932, '33, and '34, which were the 4th, 5th, and 6th years in the life of the crested wheatgrass meadow. It is of some significance, perhaps, that these years represent the peak of its productive period insofar as age is concerned. It is very doubtful that the degree of superiority indicated by the above data would be maintained indefinitely.

* See footnote on page 14.

Tower (27, 28) reports a grazing experiment with dairy cows at Moccasin, Montana. Records were obtained from crested wheatgrass, bromegrass, and sweet clover pastures for 4 years. The results show bromegrass to have a slight advantage over both crested wheatgrass and sweet clover in this locality with respect to length of pasture season and carrying capacity. The data are summarized below, together with a calculation of the acreages required for an 8-month grazing season.

	Length of grazing season	Acres required per cow	Calculated acreage for 8-month season
Bromegrass	68 days	1.50	5.3
Crested wheatgrass	67 "	1.58	5.7
Sweet clover	65 "	1.52	5.6*

Native pasture was not included in this comparative study, but it is noted that a considerably larger acreage of native grasses is required to carry an animal for a similar period.

With departure from the climatic conditions characteristic of the Northern Great Plains, the apparent superiority of cultivated grasses over native species tends to disappear. Stewart (26) states that in eastern Colorado the tame grasses (crested wheatgrass, slender wheatgrass, and bromegrass) "do not seem to furnish any more pasture on a given rainfall than the native sod, and they will not survive as lone a period of sustained drought".

Palatability and nutritive value. The green foliage of crested wheatgrass is generally regarded as highly palatable and nutritious to livestock, particularly to cattle and horses. In the palatability tables prepared by the Forest Service, the wheatgrasses as a group are given the relative maximum rating of 80 for cattle and horses, and 40 to 50 for sheep for summer grazing. As a ground-cured winter forage, they are rated at 80 for all kinds of stock. Correspondence with the office of the Forest Service at Missoula, Montana, has verified the assumption that these ratings apply to crested wheatgrass, as well as the native species.

Relative palatability varies, of course, with the character of the associated vegetation. Thus, Christ (3) observes in northern Idaho that orchard grass and timothy are grazed in preference to the wheatgrasses when all are equally available.

Analyses almost universally show crested wheatgrass to rank as high or higher than other dry-land grasses in nutrient content. In a series of analyses made at Dickinson, North Dakota, the protein content of samples ranged from a maximum of 21.01 per cent on May 10 to 9.05 per cent on August 10. The figures for bromegrass ran slightly lower, and were still lower for slender wheatgrass. At the same station, analyses of clippings taken semi-monthly showed crested wheatgrass to rank highest in protein content. Bromegrass tends to

* As soon as sweet clover matures the leaves dry and shatter, and the stems become hard and woody. It thereby becomes practically valueless for forage, and cannot be considered in the same category with ground-cured grasses.

run 1 to 2 per cent lower in crude fiber. Though the native grasses of the plains are rightly regarded as furnishing highly nutritious forage, they generally fall somewhat below the standard cultivated species in this respect (28).

Kirk (12) reports comparative analyses of native and cultivated grasses from the Canadian prairies. His figures likewise show that crested wheatgrass equals or surpasses other grasses of the region in nutritive value. He points out that crested wheatgrass is distinctly superior to all the other species analyzed with respect to the content of phosphoric acid.

HAY

Although by far the larger proportion of the acreage in ranching communities is utilized for grazing, some productive hay meadows are a necessary adjunct to the business. In a program of land use adjustment involving the regrassing of formerly cultivated land, it would seem that much of this shifted acreage could profitably be utilized for hay production. In the first place, the plowed land constitutes the best land of the region, and secondly, planted hay meadows are somewhat more productive than native ones, at least during the first 4 or 5 years after their establishment. Crested wheatgrass appears to be a most valuable species for use in this manner.

Yields. The yields of crested wheatgrass compare very favorably with other species in the northern plains. Wide fluctuations from year to year are to be expected in accordance with seasonal conditions. Yields as high as 3 tons per acre may be obtained under highly favorable circumstances; in the drier years yields may drop to one-half ton per acre, or less. According to Westover and his associates (28), crested wheatgrass gives higher average yields than bromegrass or slender wheatgrass. The latter two species may equal or surpass crested wheatgrass during the first few years after planting, but their productive life is generally shorter. Crested wheatgrass appears to be somewhat less responsive to variations in rainfall, i.e., it tends to outyield the other grasses in dry years, and to be outyielded by them in wet years. Likewise, it may outyield alfalfa in dry years, but ordinarily is surpassed by alfalfa in wet years. Westover (28) states that mixtures of these two species frequently yield more hay than either one when grown alone.

Piper (18) states that yields of crested wheatgrass hay average from one-half to 1 ton per acre under semi-arid conditions. A perusal of the extensive data compiled by Westover indicates that Piper's statement is reasonably correct.

There is a considerable body of evidence to indicate that plantings in rows are more productive in dry years than closer stands. However, the practicability of this method must be determined by local conditions, and the contemplated uses of the seeded area. Row plantings require some cultivation, the hay generally is dustier, and it may be somewhat coarser and less palatable. Planting grasses in rows appears to merit recommendation when harvesting for seed is contemplated. Otherwise, the advisability of this system is open to question. In a study of forage crops in the Northern Great Plains in 1924, Oakley and Westover (16) came to the conclusion that the row culture of grasses is not a generally feasible practice.

Palatability and nutritive value. Like the green forage, the hay of crested wheatgrass is regarded as highly palatable and nutritious. Definite palatability ratings are not available, but practical experience unanimously attests to its high value. According to Westover (28), "the stems of crested wheatgrass are generally fine, leaves medium abundant, and both stems and leaves retain their green color remarkably well". He remarks further that it compares most favorably with the famous native western wheatgrass hay, that it is readily eaten by all classes of livestock, and that horses seem to be especially fond of it. It is stated that horses often prefer it to bromegrass hay, and have been observed to take crested wheatgrass straw in preference to good bromegrass hay. Kirk (11) says that crested wheatgrass hay is equal to or better than slender wheatgrass in feeding value, and that its nutritive content is higher than that of timothy. He also makes the interesting observation that the foliage of crested wheatgrass remains green after the seed are ripe, whereas the foliage of slender wheatgrass matures simultaneously with the seed. Consequently, when harvested for seed, the threshed straw of crested wheatgrass is much more valuable for forage purposes.

Chemical analyses support the practical observation that crested wheatgrass hay is nutritious, as well as palatable. When cut during the blooming period, the protein content commonly runs from 10 to 14 per cent by dry weight (12, 28). Most other dry-land grasses, with the possible exception of bromegrass, fall somewhat lower in nutritive value when grown and cut under the same conditions. The fact that the foliage of crested wheatgrass remains green for some time after flowering is a valuable trait in that deterioration is not so rapid if cutting is delayed.

Kirk (12) notes that crested wheatgrass is remarkably free from diseases such as stem rust and ergot. In this respect, it is superior to the native slender wheatgrass and western wheatgrass.

SEED

Seeding habits. One of the virtues of crested wheatgrass is its excellent seeding habits. Except when conditions are most unfavorable, seed are produced in fair abundance. Yields run as high as 900 pounds per acre (12). Since a bushel weighs about 22 pounds (12, 18), this weight represents more than 40 bushels of seed. Such yields, however, are unusual. 250 to 300 pounds of seed per acre may be considered a good average yield (12, 28). Westover (28) states that crested wheatgrass generally has produced more seed per acre than the other grasses. He observes also that an abundance of moisture in the spring (April and May) is conducive to high yields of seed, and that row plantings usually produce more seed than close drilled fields.

The viability of the seed usually is high, running from 80 to 95 per cent (12, 28), and is retained well for 4 or 5 years. The retention of viability varies with different strains of the grass. In general, the percentage of germination may be expected to drop below 30 when the seed is 10 or more years old (28).

The seed are fairly small. According to data supplied by Kirk (12), commercial stock of crested wheatgrass runs 225,000 to 300,000 seeds per pound, and the Fairway strain runs more than 450,000 seeds per pound. There are about 185,000 seeds of slender wheatgrass in a pound, and about 137,000 seeds of bromegrass per pound. This relatively small size of crested wheatgrass seed, coupled with their high viability, explains the feasibility of seeding a smaller number of pounds per acre than is practiced with some other grasses.

Harvesting and threshing. Crested wheatgrass seed begin to shatter in the field as soon as ripe. It is recommended that the crop be cut when about one-half of the heads have turned brown. At this time most of the seed will be filled and solid, but not hard and brittle. Kirk says they should buckle rather than break when pressed endwise between the thumb and forefinger. In the northern plains, the date for harvesting usually will fall between July 15 and August 1. If the crop becomes so mature before cutting that shattering of seed is serious, it may be advisable to cut only in the forenoons while the grass contains somewhat more moisture.

It is generally recommended that the seed crop be cut with a binder and the bundles set up in narrow shocks. If the weather is dry, it should be ready for threshing after 10 to 14 days. Threshing is done with the ordinary grain separator. Certain adjustments are necessary in order to get the best results. The following suggestions are quoted from Sloan (22). Kirk (12) makes essentially the same recommendations.

1. Remove all teeth from the concaves. If one row of concave teeth is found necessary they should be placed well forward and grates, if available, used for the blank concaves.

2. Reduce the speed of the cylinder if the straw is being broken too finely.

3. Close top sections of the air inlets to the fan. Then adjust the lower part of the air inlets.

4. Adjust the chaffer so that straw and chaff will not pass through it.

5. The adjustable screen should be set so that the chaff will be lifted without carrying the seeds far back over its surface.

6. The weed opening in the bottom of the shoe should be closed.

Most weed seeds, chaff and broken straw can be removed with a good type of fanning mill. For the top sieve use zinc sieves having oblong opening from 3/64 to 4½/64 inch wide and from ¼ to ½ inch long, depending on the size of the seed. For the bottom screen use zinc sieves with circular opening of from 2¼/64 to 3½/64 inch in diameter. A cleaner of the carter disc type is very helpful for the final operation in removing round or oblong weed seeds that escape the ordinary fanning mill. Eighty-eight to 90 per cent constitutes a fair standard of purity.

Seed supply. The increased interest in grasses in recent years has resulted in a demand for crested wheatgrass seed far in excess of the supply (1, 12). Prices naturally have advanced. At present, planting programs will have to be adjusted to this situation. In general, it seems advisable to spread the available seed sparsely, or in mixture with other species, and thus introduce the grass into as large an acreage as possible. Once introduced into an area, it will spread by natural means if the conditions for its growth are at all favorable.

In the summer of 1935, most of the commercial seed houses reported their stock exhausted or much reduced, and prices ranged from 45 to 85 cents per pound. No data are at hand relative to the amount of seed harvested in 1935. In all probability, the supply will still be short of the demand, and prices will remain high. Persons or agencies desiring to purchase seed should get in touch both with commercial dealers and with the agricultural college of their state. From them, they can learn something of available supplies of seed and prices, and lay their seeding plans accordingly.

CONCLUSIONS AND RECOMMENDATIONS

As has been intimated in the foregoing discussion, crested wheatgrass appears at present to be the most generally useful grass for planting in the Northern Great Plains. During 20 years of observation at the experiment stations it has repeatedly demonstrated its superior qualities. Without doubt, it can be made to supply certain needs of the range industry better than any other species. On the basis of present experience, it seems safe to recommend its general use for regrassing formerly cultivated land throughout the northern region. It is recognized, however, that there are many local situations, preferences, and needs that will dictate the use of other forage plants. In addition, certain specific exceptions to the use of crested wheatgrass may be suggested:

1. Inasmuch as the "gumbo" soils of northwest Nebraska and western South Dakota tend to "go back" to western wheatgrass, this natural process should be permitted and encouraged. Any possible superiority of crested wheatgrass would scarcely justify the costs of seeding on these areas.

2. On lands strongly impregnated with alkali, crested wheatgrass probably holds less promise of success than the native western wheatgrass.

3. On lands that are subject to severe washing or blowing, particularly sandy soils, some more aggressive sod-former such as bromegrass probably will prove to be best suited.

Attempts to improve the native ranges had best be directed toward more conservative stocking and regulated grazing rather than toward reseeding. Under present conditions, there is no economic justification for any other policy.

Finally, it should be pointed out that, although crested wheatgrass has given some highly favorable results, and established plants are practically immune to permanent drought injury, the establishment of stands from seed will always be an uncertain undertaking. It can not be over-emphasized that seeding operations should be given the most careful attention, and the best possible conditions provided for the seedling plants. There have been, and doubtless will continue to be many failures at this point. There is a real need for specific local information with respect to the soil and climatic conditions that may favor or preclude the establishment of crested wheatgrass plants. The environmental factors will become ever more critical as attempts are made to extend the range of the species southward or westward, or on to the drier and less fertile upland soils. The local limitations of its usefulness will have to be determined largely by field trials and experience. Despite some rather laudatory publicity given to this grass, the drier and poorer upland areas of the northern plains in all probability can never be made to produce more than the scant growth of native vegetation which originally covered them. There are climatic and topographic limitations on plant production beyond which no species can go. A wider experience with crested wheatgrass in the field will gradually demonstrate its limitations, growers will acquire more definite ideas as to what may be expected from the grass in their locality, and will learn not to expect that which is environmentally impossible.

SUMMARY

Crested wheatgrass typically is a bunch grass, but develops short rhizomes and tends to form a sod. It is remarkably resistant to low temperatures and drought. One of its desirable features is its early inception of growth in the spring. It produces foliage 1 to 4 weeks in advance of the native pasture plants and such well known cultivated species as bromegrass and slender wheatgrass. Growth may cease during hot, dry weather in mid-summer, but is promptly renewed after the fall rains, and continues until freezing temperatures prevail.

Crested wheatgrass appears to be well adapted to the Northern Great Plains of the United States and adjacent Canada. It can be grown southwestward into Colorado, and possibly, parts of New Mexico where greater elevation tempers the climate. It gives good results on dry lands in the inter-mountain regions of the northwestern states. It is not adapt- to warmer climates. Trials in Kansas generally have not been promising. In the regions to which it is adapted, it appears to be almost immune to permanent drought injury, and generally outyields all other species during the drier years.

The grass is highly adaptable with respect to soils. It thrives best on fertile loams, but will grow on heavy clays, or sandy or gravelly soils of low fertility. It withstands a moderate amount of alkali, but its tolerance in this respect is not as great as that of slender wheatgrass and western wheatgrass.

A fine, firm and moist seed bed is generally deemed essential to secure a satisfactory stand. The possibilities of seeding directly on land previously cultivated, but without special seed bed preparation, have not been adequately investigated. Trials now in progress in Montana indicate that this may be a practical procedure, but results, as yet, are few and tentative.

Early spring seeding is generally recommended. The date will vary with latitude, but probably should coincide with the dates for planting spring wheat. Judgment should be exercised with regard to soil and weather conditions, and a favorable time should be chosen if possible. Some success has resulted from fall seeding. The optimum planting date, in the final analysis, is a variable local and seasonal question, and can not be stated arbitrarily.

Drilling, when feasible, undoubtedly is the best method of seeding. Normally, the seed should be covered about one-half inch deep. Slightly deeper planting may be necessary if the top soil is dry, but emergence of seedlings is markedly reduced when the planting depth is greater than 1 inch.

The rate of seeding will vary with the climatic conditions, the cost of seed, and the potential value of an immediate full stand. Rates of 6 to 10 pounds of seed per acre usually are recommended for the more arid regions, though 12 to 15 pounds may be sown where moisture is more plentiful. With the present scarcity and high prices of seed, it may be practical to forego the prospects of an immediate full stand and seed in rows or in drill-width strips several rods apart. Row seeding can be done by plugging certain spouts on an ordinary drill. The rows may be spaced 12 to 42 inches apart, and the seed sown at rates of 2 to 6

pounds per acre. Such a sowing may be expected to thicken to a full cover in 3 or 4 years. Both volunteer seeding and vegetative spread will enter into the process.

Nurse crops are not generally recommended except where the soils are inclined to blow.

Crested wheatgrass may profitably be seeded in mixture with other grasses, or with such legumes as alfalfa and sweet clover. Such mixtures oftentimes result in an increase in both the quantity and quality of forage produced.

When planted in rows, some cultivation the first season may be desirable as a weed-controlling measure. If the growth of weeds is not too dense, it may be advisable to let them stand for the purpose of catching snow during the winter. They can then be burned on a windy day in early spring before the new growth of grass starts. When the rows of grass are fully established, weed growth usually is fairly well controlled. However, some cultivation will be necessary to destroy grass seedlings, as well as the few inevitable weeds, if the rows are to be maintained.

When the seed is close-drilled or broadcasted, no care is necessary except to withhold grazing during the first season, and to regulate grazing thereafter. If weeds appear to be a menace the first season, they may be clipped high with a mower before blooming.

Old stands gradually decline in productivity. Fertilization, either by direct application, or by seeding in legumes, effects some improvement. Cultivation has not generally given sufficiently favorable results to justify its cost.

Crested wheatgrass furnishes highly palatable and nutritious grazing to all kinds of stock. Sheep relish it somewhat less than horses and cattle. It cures well on the ground and makes choice winter forage. Perhaps its greatest value lies in its early spring and late fall growth. Stock can thus be provided with green forage over a longer period than would otherwise be possible. The grass is not dependable for summer grazing except as the spring growth is allowed to accumulate on the ground. It is remarkably tolerant to close grazing and trampling. In carrying capacity, it compares very favorably with bromegrass and sweet clover, and usually surpasses the native ranges.

Crested wheatgrass also makes excellent hay. In color, palatability, and nutritive value, it compares favorably with western wheatgrass, and surpasses timothy, slender wheatgrass, and in some

respects, bromegrass. Yields in the Northern Great Plains average from one-half to 1 ton per acre. Its productive life usually is longer than that of slender wheatgrass and bromegrass, and in dry years, it frequently outyields these species.

The species has excellent seed habits. Seed are produced in abundance, the viability is high and is retained for 4 or 5 years. The seeds are small, being only about one-half the size of the seeds of slender wheatgrass. The weight runs about 22 pounds to the bushel. Yields of seed range from occasional failure to 900 pounds per acre. 250 to 300 pounds of seed per acre is to be considered a fair yield. Plantings in rows usually give the highest production of seed.

The seed shatters easily when mature, hence the seed crop is best cut while some green still shows in the heads, or when about one-half of the heads have turned brown. At this time, most of the seeds are filled and solid, but not hard and brittle. Harvesting can be done with an ordinary grain binder; threshing can be done with the ordinary grain separator when the machine is properly adjusted.

Present supplies of seed are short of the demand, and planting programs must be governed accordingly. During the summer of 1935, prices ranged from 45 to 85 cents per pound.

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